OwlDE : making ODEs first class Owl citizens

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OCaml Scientific Computing

Owl in brief - the library

Framework for Scientific Programming in OCaml

as fast as C but as concise as python

- GENERIC NDARRAY IMPLEMENTATION (including pure OCaml base layer)
- LARGE LINEAR ALGEBRA AND OPTIMIZATION API
- DATAFRAMES AND ADVANCED STATISTICAL ANALYSIS LIBRARY
- POWERFUL ALGORITMIC DIFFERENTIATION ENGINE
- NEURAL NETWORK MODULE
- PARALLEL AND DISTRIBUTED COMPUTATION ENGINE
- SWAPPABLE BACKENDS (CPU, GPU, JAVASCRIPT, ...)

MORE ON THIS IN 30 MINUTES IN @Jianxin TALK

Owl in brief - the team

LIANG WANG

CREATED OWL AND GUIDES ITS DESIGN

JIANXIN ZHAO

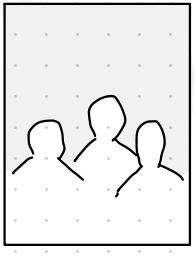
GPU/TPU BACKEND

MARCELO SERI

BUILD & RELEASE, ODEs AND DYNAMICAL SYSTEMS

TA-CHU KAO

ALGODIFF, NEURAL NETWORK'S, ODES



A GROWING COMMUNITY OF DEVELOPERS, RESEARCHERS AND STUDENTS. CURRENTLY ACTIVE PROJECTS WITH **GUILLAUME HENNEQUIN** AND **KC SIVARAMAKRISHNAN** AND SOME OF THEIR STUDENTS.

Scientific libraries and Ordinary Differential Equations I

- Ordinary Differential Equations model a large class of Physical, Chemical and Biological systems
- Recently Neural ODE (arXiv:1806.07366 and followups) made them relevant also for neural networks and machine learning
- They appear everywhere in Mathematics, Physics and the other scientific disciplines, and having interactive demos helps a lot for the understanding (useful when teaching and learning)

Scientific libraries and Ordinary Differential Equations II

PRESENT IN THE ECOSYSTEM OF PRETTY MUCH ANY PROGRAMMING LANGUAGE WITH VARIOUS DEGREES OF COMPLETENESS AND FLEXIBILITY, INCLUDING OCAML! (FOR AN OVERVIEW: DOI 10.15200/winn.153459.98975)

AMONG MOST LIVELY ECOSYSTEMS

- **PYTHON:** NUMPY (CPU) / NUMBA (GPU), SCIPY, TENSORFLOW / PYTORCH, JAX (NN & ALGO DIFF)
- **JULIA:** JULIADIFFEQ, FLUX, ZYGOTE (arXiv:1810.07951) (NN & FULL PROGRAM DIFFERENTIATION)

↑ They also include amazing plotting libraries & can call each other...

Owl/ODE · a library to integrate Ordinary Differential Equations

Owl provides NDArray, Linear Algebra, AlgoDiff, Neural Networks and Swappable Backends (CPU, GPU, JavaScript).

OCaml provides Powerful Type System, easy access to C libraries, reasonable Conciseness and Good Speed.

ODEPACK and SundialsML provide wrappers to fast and solid ODE solvers

OwlODE collects all of the above and Native OCaml Impl. of Fixed Step, Adaptive and Symplectic ODE solvers under a simple, common interface

Bonus: pyml + matplotlib, gp + jupLot, jupyter, js_of_ocaml, npy

Demo Time !

- OwlDE structure and Interface
- Jupiter Notebook and Js_of_Ocaml-based Interactive Examples
- N-Body simulation w. comparison with Python & Numpy-based Impl
- Neural Ode (courtesy of TA-Chu Kao)

More examples are not demonstrated but are available at

github.com/mseri/owlde-demo-icfp2019
github.com/tachukao/adjoint_ode
github.com/owlbarn/owl_ode

The Owl experience

THE GOOD

- complete and fast framework
- trivial to do large refactoring, even after having left the code to rot
- easy to compile to fast code or standalone javascript

THE BAD

- terrible error messages (fixed -ish)
- practically impossible to build (fixed -ish)
- entangled component, side effects on import (fixed)
- well documented but the documentation is getting stale (design in progress)

A glimpse into the future

- Accelerator project [CPU/GPU/TPU] ← MORE ON THIS IN 30 MINUTES...
- New sparse data structure (and no more `eigen` pain)
- Refreshed tutorial + online book
- New integrators in owl-ode & support for event handling
- High dimensional root finding module

A vision for the project

Owl Ndarray could provide a building block to unify the scientific ecosystem in the OCaml world, but development is slowed down by the limited support.

ANY TYPE OF CONTRIBUTION IS WELCOME: bug reports, pull requests, feedback, collaborations in subprojects, research proposals, collaborations with interested industries, ...

Current open sub-projects (seeking help) can be found at

OCAML.XYZ/PROJECT/PROPOSAL.HTML